THE EFFECTS OF FLUCTUATING FLOWS

ON BREEDING BIRDS

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Introduction

The breeding birds of the Colorado River corridor have been greatly influenced by the construction and operation of Glen Canyon Dam. The dam has mainly had an indirect, positive influence on birds by creating new areas of riparian habitat in the predam scour zone. Beginning in 1963, the dam prevented flooding which had historically scoured away any vegetation below the pre-dam high water line. This new habitat, dominated by introduced tamarisk shrubs, was colonized by riparian breeding birds over the next decade. Several species of birds expanded their breeding ranges upriver to take advantage of the new habitat. However, Lake Powell reached maximum storage capacity for the first time in 1980. A series of large surplus water releases from the dam which approximated predam flood conditions and a need to modify the operating criteria of Glen Canyon Dam led to management concern over the future well-being of breeding birds in the river corridor.

Objectives

This study was designed to explore the relationships between the operation of Glen Canyon Dam and breeding birds of the Colorado River in Glen Canyon National Recreation Area downstream from the dam and in Grand Canyon National Park. The purpose was to identify the effects of fluctuating flows, as well as those occasional surplus water releases above 31,000 cfs, on birds that nested in the riparian zone of the river corridor.

The relationship between fluctuating flows and breeding birds was examined in the framework of four primary objectives. 1) The number of active nests that was

inundated at various flow levels was documented for each species. Inundation rates showed which species were most likely to be directly influenced by fluctuating flows. 2) The density and diversity of breeding birds was measured in both the mesquite-dominated old-high-water-zone (OHWZ) and tamarisk-dominated new-high-water-zone (NHWZ). Density and diversity information illustrated the relative importance of these two major habitat zones to the overall riparian bird community, in the event that fluctuating flows were causing long-term changes in either zone. 3) The nesting habitat preferences of obligate riparian birds in the NHWZ were documented and compared. Obligate riparian birds nested only in riparian habitat and would therefore be most sensitive to long-term habitat changes that could result from fluctuating flows. 4) The population density of five indicator species of birds was determined from 1982 to 1986 to reveal population fluctuations that may have been influenced by Glen Canyon Dam.

Methods

Nests of riparian birds were located throughout the river corridor from 1982 to 1985. Information on the timing of nesting, and nest heights relative to both the ground and the surface of the water were taken for each nest. Flow levels that would inundate specific nests were calculated, based on nest heights and on flow rate and gauge height information supplied by the U.S. Geological Survey for the Lees Ferry and Phantom Ranch gauging stations. Much of the inundation data were gathered during the surplus water release of 93,000 cfs in June 1983. This large release allowed the direct measurement of water levels at many nests which had been located and mapped in 1982 and early 1983.

Breeding birds were censused from 1984 to 1986 at ten study sites between Glen Canyon Dam and Diamond Creek. Each study site consisted of paired study plots, one each in the OHWZ and NHWZ. The census technique used was the absolute count method, in which the observer counted all birds seen or heard in the small linear study sites (Emlen 1971). The number of pairs of birds at each study plot were transformed to the numbers of pairs per 40 hectares, the standard unit of measurement in reporting avian densities. Avian densities in the OHWZ and NHWZ were statistically compared using the Wilcoxon signed rank test.

Discriminant function analysis, a multivariate statistical technique, was used to compare the nesting habitat preferences of obligate riparian birds in the NHWZ. Habitat use was only analyzed for the NHWZ since it was the zone most influenced by fluctuating flows. Also, most obligate riparian birds nested primarily or exclusively in the NHWZ. Ten variables representing vegetation structure

and shrub species composition were measured in 0.04 hectare circles centered at nest sites. The raw data for each of these variables were mathematically transformed and statistically analyzed. This indicated the relative habitat preferences of each species within three-dimensional "habitat space" represented by a habitat model.

The population densities of five indicator species of obligate riparian birds were determined from 1982 to 1986 using an indirect count census (Schemnitz 1980). The indirect count, or call count (Bull 1981), was a true census of the number of singing male birds heard on an 18-day, oar-powered raft trip between Lees Ferry and Diamond Creek at the height of the breeding season for each species. This census resulted in an index to the population densities of the five species under study. An index is a census of some variable (in this case, bird songs) related to the true number of animals being studied which reliably identifies changes in annual density. Singing male birds were counted primarily from 08:00 to 12:00 hours each morning as the boats floated downstream. The five indicator species were chosen because 1) they were all highly vocal at the peak of the breeding season, and because 2) they represented a wide range of abundance, distribution, and habitat use patterns, a combination representing most of the variability exhibited by the entire riparian breeding bird community.

Results

Fluctuating flows of up to 31,000 cfs had little direct effect on breeding birds. At this release level, only a single Black-chinned Hummingbird nest was known to have been inundated, representing less than 1% of the population of that species in the river corridor.

Surplus water releases above 31,000 cfs inundated substantial numbers of bird nests, primarily those of Common Yellowthroat, Bell's Vireo, and Yellow-breasted Chat. These three species were most susceptible to nest inundation because their nests were located both closest to the water's edge and lowest to the ground. Surplus water releases up to 40,000 cfs inundated approximately 90% of all Common Yellowthroat nests; releases above 40,000 cfs began to inundate susbtantial numbers of Bell's Vireo and Yellow-breasted Chat nests (Figure 1). Small numbers of the nests of other species were inundated, including Black Phoebe, Say's Phoebe, and Violet-green Swallow. The surplus water release of June 1983 coincided with the May to July peak of breeding for most species, causing a higher inundation rate of active nests.

Tamarisk habitats in the NHWZ exhibited a significantly higher density of breeding birds than mesquite habitats in

the OHWZ (Table 1). Avian diversity was similar in both zones. The density of breeding birds in several well-developed riparian areas of both zones exceeded 800 pairs per 40 hectares and therefore ranked among the highest densities ever reported for non-colonial breeding birds in North America.

The eleven species of obligate riparian birds known to breed in the NHWZ differed in their choice of nesting habitat, both in the range and type of habitats chosen. Figure 2 identifies the relative nesting habitat chosen by each species within the "habitat space" of the statistical model. Bell's Vireo and American Coot selected nesting habitat that was the most dissimilar; Yellow Warbler and Willow Flycatcher were the most similar in their choice of nesting habitat. Bell's Vireo, Willow Flycatcher, and Yellow Warbler were the most extreme generalists in habitat choice in the river corridor, while American Coot, Blue Grosbeak, and Northern (Bullock's Oriole) were the most specialized.

The abundance of all five indicator species of birds has increased since 1976 (Table 2). A decline in numbers after the 1983 surplus water release was observed in Bell's Vireo, Yellow Warbler, and Common Yellowthroat populations. The declines were largely attributed to the effects of the 1983 surplus water release: nest inundation combined with habitat loss through streambank erosion. These species had all recovered to or surpassed their pre-1983 densities by 1986 with the exception of Common Yellowthroat, for which pre-1983 density information was partly lacking. The recovery times exhibited by these indicator species identified a breeding bird recovery cycle of approximately 2 to 3 years in response to the effects of the 1983 surplus water release.

Conclusions

The extent and timing of surplus water releases above 31,000 cfs during the breeding season have the potential to inundate a substantial number of the nests of certain birds. Management attention should be focused on the fact that breeding for most species along the river peaks from May to July, indicating that surplus releases should be avoided at this time. Many birds will renest if their initial nesting attempt is unsuccessful, but only if adequate time remains for the effort during their normal breeding period. The presence of very high water throughout most of the summer of 1983 prevented many birds from renesting, further reducing that season's nesting success.

If surplus releases during the breeding season cannot be avoided, then releases should be increased as soon as

surplus water is predicted. These surplus releases should either remain constant or decrease slightly to allow birds to adjust to the higher water levels and renest.

Certain obligate riparian birds are especially sensitive to future management of fluctuating flows. These species include those habitat specialists that are (1) restricted to the NHWZ, (2) are of rare or localized occurrence, or (3) nest closest to the water's edge or in marshy habitats. This management-sensitive group includes American Coot, Willow Flycatcher (although it was identified as a generalist), Common Yellowthroat, and Bullock's Oriole. Any future habitat change or loss would have a disproportionately large effect on these species.

The most serious long-term management consideration with respect to breeding birds is the potential for loss of riparian habitat through riverbank erosion. If fluctuating flows are causing riverbank erosion, then the overall density and diversity of breeding birds will decline because of a loss of avian breeding habitat. Any decline of this sort would certainly occur in the NHWZ, which presently exhibits the highest density of birds. Likewise, fluctuating flows shown to stabilize or increase the extent of river terraces supporting riparian vegetation would be of long-term benefit to birdlife.

Periodic flooding caused by surplus water releases, even if it did cause short-term inundation of the nests of some species of birds, could be of long-term benefit to the overall breeding bird community. By maintaining the earlier successional stages of vegetation needed by some species, periodic flooding could be a positive management tool, provided that riverbank erosion associated with flooding were not excessive.

Overall, fluctuating flows with restricted maximum releases (such as not exceeding 25,000 cfs) would be of the greatest long-term benefit to birds. Some changes in the birdlife of the river corridor will continue to occur regardless of how the dam is operated. However, management now has the capability to predict, direct, and even enhance this process of change in the breeding bird community.

Literature Cited

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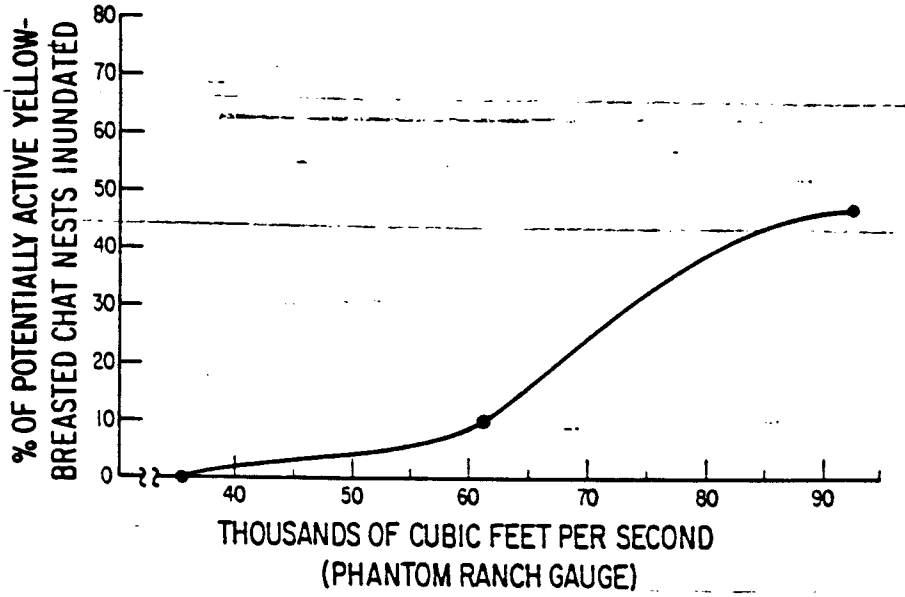
Figure Captions

Figure 1. Percent of Bell's Vireo and Yellow-breasted Chat nests inundated at various release levels, June 1983. Dots represent known data points.

Figure 2. Location of the relative habitat preferences in three-dimensional "habitat space" of the eleven species of species of obligate riparian bird breeding in the river corridor. Increasing values on the first function indicate a trend toward taller vegetation and habitat patchiness. Decreasing values on the second function indicate marshy or dense, low vegetation. The third function separates species based on a complex interaction between ten habitat variables. Species codes are: AC=American Coot, WF=Willow Flycatcher, BV=Bell's Vireo, YW=Yellow Warbler, YbC=Yellow-breasted Chat, CY=Common Yellowthroat, IB=Indigo Bunting, BG=Blue Grosbeak, HO=Hooded Oriole, BO=Northern (Bullock's) Oriole, and GtG=Great-tailed Grackle.


% OF POTENTIALLY ACTIVE YELLOW-BREASTED CHAT NESTS INUNDATED
80
70
60
50
40
30
20
10
0
40
50
60
70
80
90
THOUSANDS OF CUBIC FEET PER SECOND
(PHANTOM RANCH GAUGE)

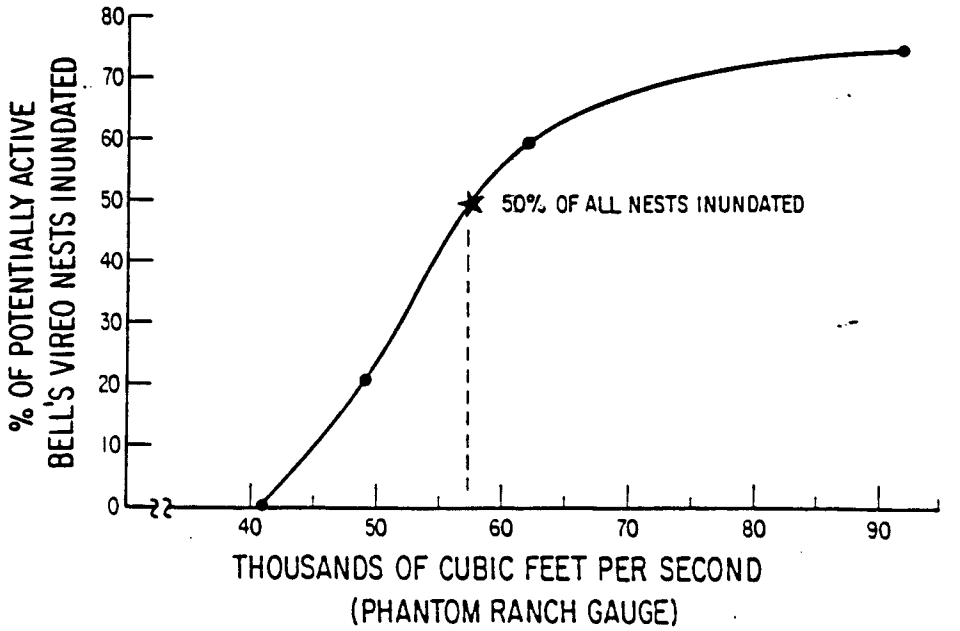

% OF POTENTIALLY ACTIVE BELL'S VIREO NESTS INUNDATED
80
70
60
50
40
30
20
10
0
50% OF ALL NESTS INUNDATED
40
50
60
70
80
90
THOUSANDS OF CUBIC FEET PER SECOND
(PHANTOM RANCH GAUGE)

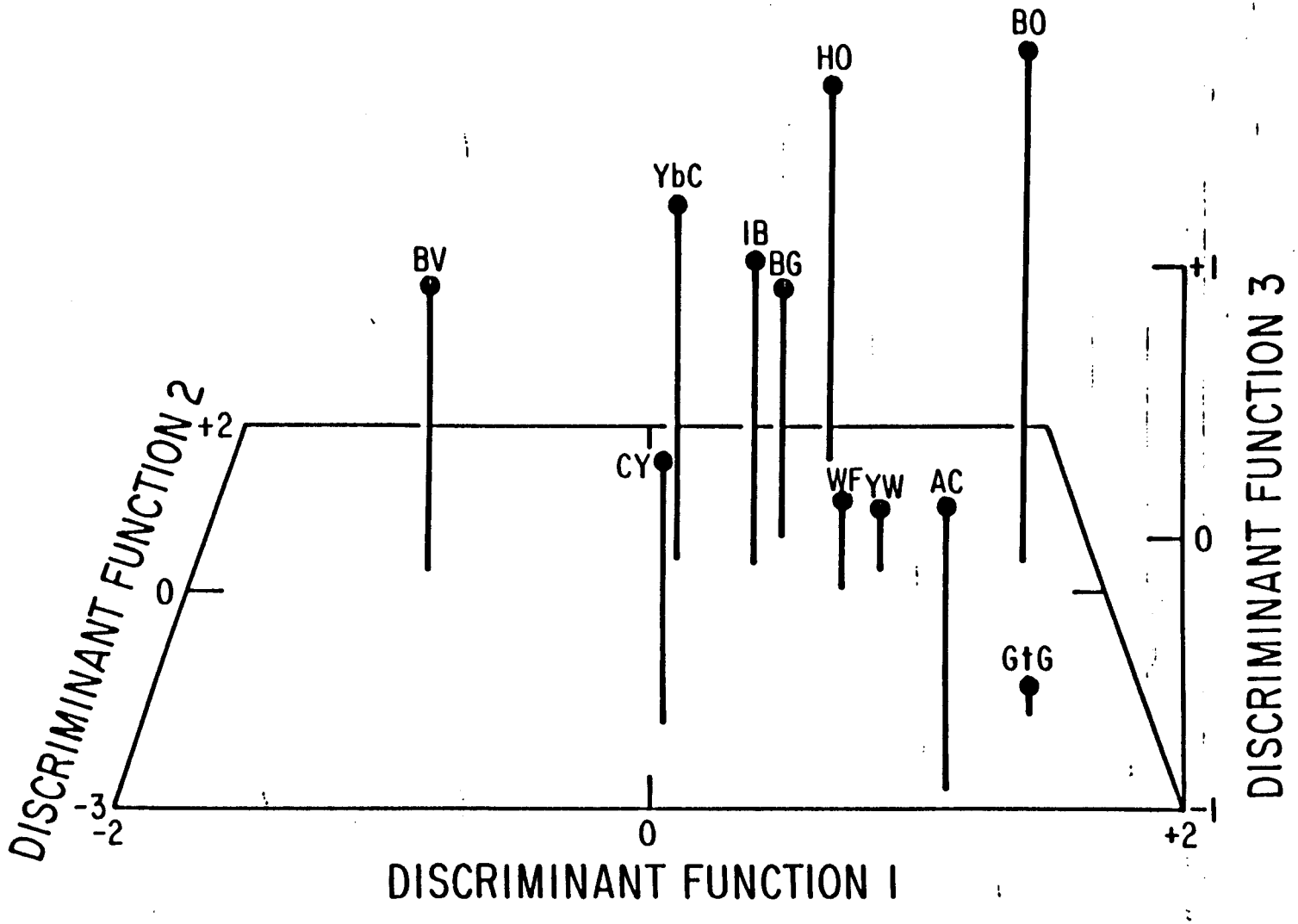
Figure 1

Raw Data for Fig. 1.

	Data points	
	cfs	%
Yellowbreasted Chat:	36,000	0 %
figure	62,000	11
	93,000	47
Bell's Vireo	41,000	0
figure	49,000	21
	57,000	50
	62,000	60
	93,000	75%

Table 1. Breeding bird density (pairs/40 ha) in OHWZ and NHWZ sites along the Colorado River in Glen and Grand canyons, 1984-1986.

Site Number	Location	1984 OHWZ	1984 NHWZ	1985 OHWZ	1985 NHWZ	1986 OHWZ	1986 NHWZ
01	Glen Canyon/Lees Ferry	318	441	200	552	282	338
02	Saddle Canyon	538	486	300	571	388	371
03	Cardenas Canyon	747	941	613	824	1000	717
04	Lower Bass Camp	200	500	300	100	200	200
05	Forster Canyon	200	400	200	400	200	250
06	National Canyon	182	600	73	300	109	300
07	Stairway Canyon	565	857	529	1085	565	771
08	Parashant Wash	986	1200	943	1200	514	480
09	Granite Park	357	480	229	220	182	320
10	220-Mile Canyon/ Granite Springs Canyon	400	200	400	400	556	200
Mean Density		449	611	379	565	400	395


BO
HO
YbC
IB
BG
BV
CY
WF
YW
AC
GtG
+2
0
-3
-2
0
+2
+1
0
-1
DISCRIMINANT FUNCTION 2
DISCRIMINANT FUNCTION 3
DISCRIMINANT FUNCTION I

Raw data for Figure 2.

[redacted] Species mean vectors for each of the three discriminant functions.

Species	Function 1	Function 2	Function 3
American Coot	1.10	-2.82	0.03
Willow Flycatcher	0.99	0.03	-0.64
Bell's Vireo	-1.06	0.24	0.03
Yellow Warbler	0.99	0.38	-0.79
Common Yellowthroat	0.07	-1.74	-0.05
Yellow-breasted Chat	0.11	0.39	0.27
Blue Grosbeak	0.62	0.72	-0.10
Indigo Bunting	0.43	0.37	0.10
Great-tailed Grackle	1.53	-0.51	-0.90
Hooded Oriole	0.85	1.45	0.62
Northern (Bullock's) Oriole	1.68	0.21	0.85

Table 2. Yearly index to the population densities of five indicator species of obligate riparian birds between Lees Ferry and Diamond Creek along the Colorado River in Grand Canyon, 1976 to 1986.

Species	Number of Singing Males Heard					
	1976	1982	1983	1984	1985	1986
Willow Flycatcher*	1+	2	4	4	8	11
Bell's Vireo**	67++	135	78+++	92	75	121
Yellow Warbler***	17+	32	39	33	61	80
Common Yellowthroat***	8+	-	-	21	21	29
Yellow-breasted Chat*	18+	46	53	65	62	101

* Census data from June of each year.
** Census data from mid-April to early May of each year.
*** Census data from late May to June of each year.
\+ From Carothers and Sharber (1976). Average absolute density for April, May, and June, 1974 to 1976.
++ From the April 1976 field journal of S.W. Carothers (Brown et al. 1983).
+++ Census inaccurate due to poor weather and high winds.